

INTEGRATE PROGRAM

Market Trends & Opportunities

October 10, 2019

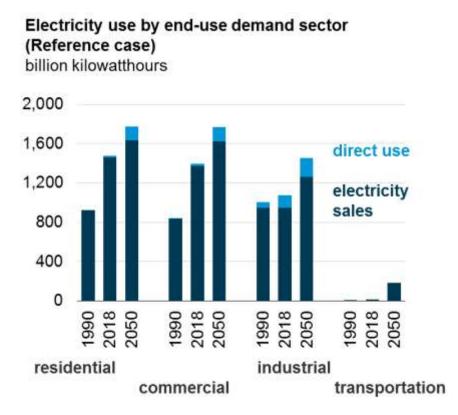
Outline

- Trends in Global Energy Markets
- Stationary Power
- Large Transport
- Business Model Canvas & Value Proposition
- Conclusions

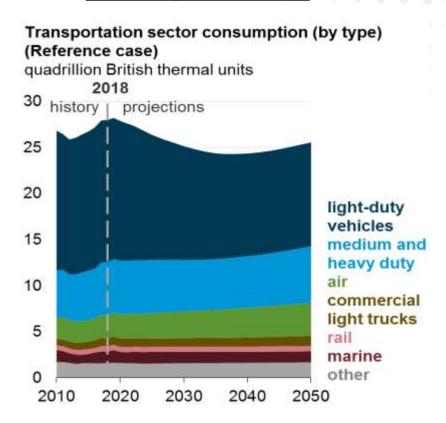


US ENERGY DEMAND FORECASTS

Electric



Transportation



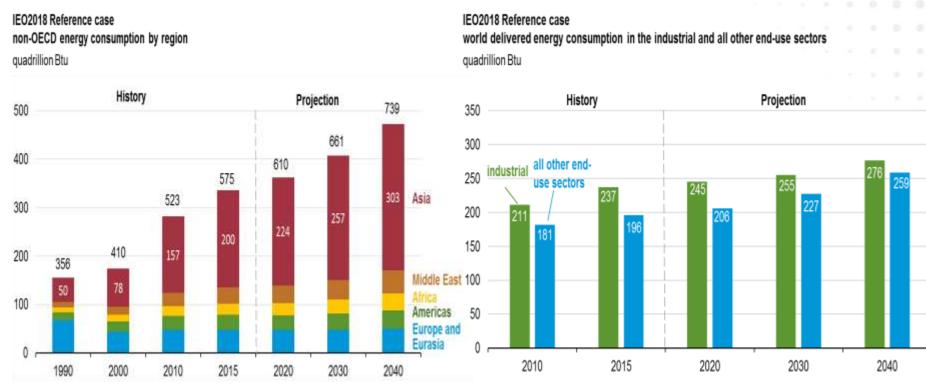
Continued modest growth in overall energy demand in the US



INTERNATIONAL ENERGY DEMAND FORECASTS

Regional

Sectoral

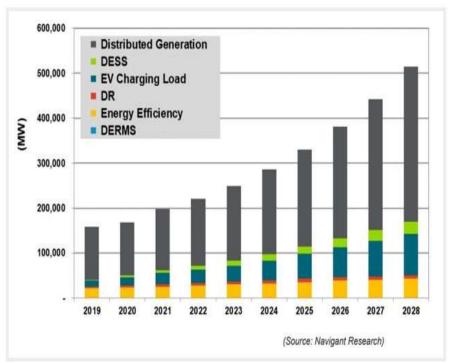


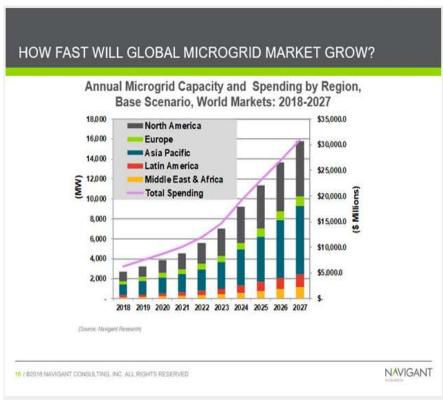
 Significant growth forecasted for energy consumption globally driven by continued industrial growth in Asia



STATIONARY POWER TRENDS

Annual Installed Total Distributed Energy Resource Power Capacity by Technology, World Markets: 2019-2028





- Distributed generation should continue to grow (large share for solar)
- Globally forecasts suggest increased penetration of microgrids



STATIONARY POWER - NEW ENTRANTS

	EV charging	Energy management	Storage	PV	Demand response & VPP	Non-PV generation
	NewMotionGreenlotsAmple Inc	Sense LabsInspireGridPoint	• Sonnen • Geli	SunseapClean Tech SolarSolarNow	MP2 EnergyLimejumpSteamaCoAutogrid Systems	Husk Power Systems
TOTAL	G2 MobilityChargePoint	GreenFlexTendril NetworksTado	SunvergeStem	SunPowerZola Electric	Autogrid Systems	United Wind
bp	ChargemasterFreeWirePowerShare	 Voltaware Services 	StoreDot	 Lightsource Renewables 	None	• None
Chevron	ChargePoint	• None	• None	• None	• None	• None
(onMobil	• None	 None 	• None	• None	• None	• None

Legend: In-house and M&A, Strategic investment, Partnership

 European oil and gas companies expanding into distributed energy resources businesses



STATIONARY POWER SEGMENTS





- Largest growing segment
- Existing customer base (backup power)

- Cost targets less challenging (diesel displacement)
- Utility not involved



- Cost challenges (need to compete with grid power)
- Utility adoption

- Smaller segment
- Remote sites not easy to access (higher costs)



LARGE TRANSPORT OUTLOOK

Global Transportation

Chart 9

Revenue growth (local currency)

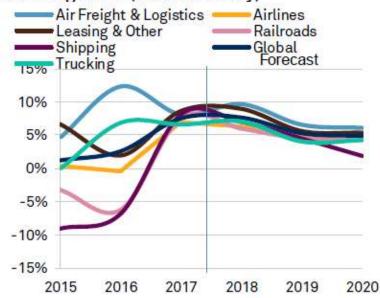


Chart 4

Ratings outlooks by subsector





LARGE TRANSPORT SUBSECTOR TRENDS



Marine

- New sulfur standards by 2020 and potential targets for GHG in 2030 and beyond
- Slow and steady growth globally



Aviation

- Continued pressure for emissions reductions
- Growing interest in electrification (short haul early entry)
- Global growth story



Rail

- Passenger rail electrification common
- Freight rail electrification challenging (10s MW)
- Asian markets will continue to grow



LARGE TRANSPORT INNOVATION TRENDS









'World's largest fleet of fuel cell trains' ordered

21 May 2219



(DERMANY Following a European tandor, the Follow roting stock subsidiary of Hison-Main transport authority RMV has awarded Anton a contract to supply and support a fixed of 27 fixed cell multiple-units.

 Could systems proposed under the INTEGRATE program be the "bridging" solution?



that want Principles, and the interests of Asian and Ato, in condition Demograph, in comment.

MARINE POWER PLAYERS

Environmental performance of top ten shipping companies

Shipping company	CO2 emissions	Sulfur emissions	Ship-to-shore power connection?	Meets IMO's Ballast Water Convention (deadline 2021)?	Ship recycling – (Hong Kong Convention)?	
MAERSK	Has target	Has initiatives	Retrofit ongoing	Compliant	Compliant	
Mediterranean Shipping Company	Has initiatives	Has initiatives	Retrofit ongoing	Compliant	No activity	
cosco	Has initiatives	Has initiatives	No activity	Compliant	Compliant	
CMA CGM	Has target	Has initiatives	Retrofit ongoing	Compliant	Compliant	
# Hapag-Lloyd	Has target	Has initiatives	Retrofit ongoing	Compliant	Compliant	
Ocean Network Express	Has initiatives	No activity	No activity	Efforts underway	No activity	
EVERGREEN	Has initiatives	Has initiatives	New ships fitted	Efforts underway	No activity	
YANG MING	Has initiatives	Has initiatives	No activity	Efforts underway	Compliant	
Pacific Inter- national Lines	Has initiatives	No activity	Retrofit ongoing	Efforts underway	No activity	
HMM	Has target	Has initiatives	Retrofit ongoing	Compliant	Compliant	

Source: BloombergNEF. Note: For details, see appendix 1. Top 10 international container shipping companies by TEU capacity. 1 TEU = the equivalent of a container 20 feet long and 8 feet wide; Gray = no progress; Light blue = some progress; Blue = good progress.

Sulfur and eventually GHG standards will require new propulsion solutions



AVIATION PLAYERS

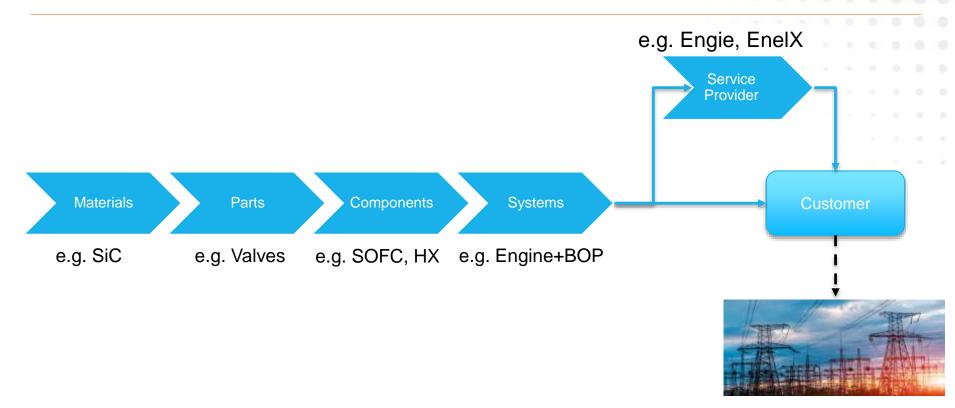


World's Largest Airlines By Fleet Size

Rank	Arline	Country	Fleet (June 2016)		
1	American Airlines	United States	1,789		
2	Delta Air Lines	United States	1,330		
3	United Airlines	United States	1,229		
4	Southwest Airlines	United States	720		
5	FedEx Express	United States	688		
6	China Southern Airlines	China	515		
7	China Eastern Airlines	China	429		
8	Air Canada	Canada	404		
9	Air China	China	384		
10	Ryanair	Ireland	349		



VALUE CHAIN



- Grid connected system will likely require going through a service provider for some companies
- Off grid and transportation sector systems may need to work with a "system solution provider" to get to end customer, e.g. Halliburton, Maersk, Boeing
- Further down the value chain, the more compressed the margin unless product offers a significant benefit and is not easily replicable
- Supply chain issues (novel materials, tooling etc.), needed for unique components can also prove challenging for economics



SYSTEM BUSINESS MODEL CANVAS



Key Partners

OEM (fuel cell or engine or turbine manufacturers) Examples - IR, Cummins, Caterpillar, Ballard, Fuel Cell Energy, Doosan, GE, Siemens etc.



Key Activities

Similar to those performed by OEM (supply chain management, manufacturing, sales/marketing, servicing etc.)



Key Resources

Manufacturing facilities Operating system (People, Process, Tools)



Value Propositions

Value Propositions
System has to displace
incumbent technology
(typically diesel or gas
engines/turbines) based
on:

- LCOE (combination of capital + O&M costs)
- Deliver within space constraints
- Better emissions profile
- Better noise profile
- System connectivity features (ability to monitor, diagnose and fix problems remotely)



Customer Relationships

Provided by strategic partner

Channels

Provided by strategic

partner



Customer Segments

Depending on the size of the system solutions could be provided to:

- Industrial customers (grid connected and off grid)
- Commercial buildings
- Residential
- Direct power distributors (microgrids)
- Maritime
- Aviation



- Working with a strong commercialization partner is essential because this an OEM play
- Depending upon size and scalability, multiple segments could be served
- Value proposition will be driven by LCOE
- Certain segments could pay for additional features such as reduced emission, noise etc.
- Ability to remotely monitor systems is becoming increasingly important
- Manufacturing cost model will be required in Stage 2 and beyond to "sell" concept to next stage funders



Cost Structure

Need a basic manufacturing cost model to determine cost of producing and servicing.



Revenue Streams

Can be secured through partner



Social & Environmental Cost

Manufacturing footprint, supply chain



Social & Environmental Benefit

Lower emissions, noise, enhanced energy security, jobs



COMPONENT BUSINESS MODEL CANVAS



Key Partners

Requires scale up partner for manufacturing, either fuel cells or heat exchangers



Key Activities

Similar to those performed by OEM (supply chain management, manufacturing. sales/marketing, servicing etc.)



Value Propositions

Value Propositions Component has to significantly reduce costs or be cost neutral to incumbent technology while enhancing efficiency.



Customer Relationships

Provided by strategic partner

Channels

Provided by strategic

bartner



Customer Segments

Depending on the size and scalability of the product, it should have access to similar markets are system solutions. Heat exchangers could extend beyond power markets to adjacent markets where cooling and heating requirements match the product performance envelope.





Key Hypotheses:

- Existing manufacturers could launch component improvements as the next generation of products
- Since components are part of the CAPEX and O&M (non fuel) cost structures, need them to improve efficiencies while remaining cost neutral (if not lower)
- Component manufacturers have greater flexibility in terms of products reaching multiple, related markets (but more competition)
- Licensing revenue a more likely path for university or lab demonstrations/pilots

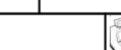


Need a basic manufacturing cost model to determine cost of

Operating system



Manufacturing facilities (People, Process, Tools)



Revenue Streams

Licensing revenue appears to be most likely. Need to go into an existing product line, ideally.



producing.

Social & Environmental Cost

Cost Structure

Manufacturing footprint, supply chain.



Social & Environmental Benefit

Not as direct, will be realized more at the system level.



TEA ASSUMPTIONS

Table 2. Cost and performance characteristics of new central station electricity generating technologies

Technology	First available year¹	Size (MW)	Lead time (years)	Base overnight cost (2018 \$/kW)	Project contin- gency factor ²	Techno- logical optimism factor ³	Total overnight cost ^{4,10} (2018 \$/kW)	Variable O&M ⁵ (2018 \$/MWh)	Fixed O&M (2018\$/ kW/yr)	Heat rate ⁶ (Btu/kWh)	Final heat rate (Btu/kWh)
Coal with 30% carbon sequestration (CCS)	2022	650	4	4,713	1.07	1.03	5,169	7.31	72.12	9,750	9,221
Coal with 90% CCS Conv gas/oil combined cycle	2022	650	4	5,212	1.07	1.03	5,716	9.89	83.75	11,650	9,257
(cc)	2021	702	3	952	1.05	1.00	999	3.61	11.33	6,600	6,350
Adv gas/oil CC	2021	1,100	3	736	1.08	1.00	794	2.06	10.30	6,300	6,200
Adv CC with CCS	2021	340	3	1,963	1.08	1.04	2,205	7.34	34.43	7,525	7,493
Internal combustion engine	2020	85	2	1,306	1.05	1.00	1,371	6.03	7.11	8,500	8,160
Conv combustion turbine ⁷	2020	100	2	1,072	1.05	1.00	1,126	3.61	18.03	9,840	9,600
Adv combustion turbine	2020	237	2	658	1.05	1.00	691	11.02	7.01	9,800	8,550
Fuel cells	2021	10	3	6,250	1.05	1.10	7,197	46.56	0.00	9,500	6,960
Adv nuclear	2022	2,234	6	5,224	1.10	1.05	6,034	2.37	103.31	10,461	10,461
Distributed generation – base	2021	2	3	1,501	1.05	1.00	1,576	8.40	18.90	8,958	8,900
Distributed generation – peak	2020	1	2	1,804	1.05	1.00	1,894	8.40	18.90	9,948	9,880
Battery storage	2019	30	1	1,857	1.05	1.00	1,950	7.26	36.32	NA	NA
Biomass	2022	50	4	3,642	1.07	1.00	3,900	5.70	114.39	13,500	13,500
Geothermal ^{8,9}	2022	50	4	2,654	1.05	1.00	2,787	0.00	122.28	NA	NA
MSW - landfill gas	2021	50	3	8,313	1.07	1.00	8,895	9.47	425.38	18,000	18,000
Conventional hydropower9	2022	500	4	2,680	1.10	1.00	2,948	1.36	40.85	NA	NA
Wind ¹⁰	2021	100	3	1,518	1.07	1.00	1,624	0.00	48.42	NA	NA
Wind offshore ⁸	2022	400	4	4,758	1.10	1.25	6,542	0.00	80.14	NA	NA
Solar thermal ⁸	2021	100	3	4,011	1.07	1.00	4,291	0.00	72.84	NA	NA
Solar PV - tracking ^{8, 10, 11}	2020	150	2	1,876	1.05	1.00	1,969	0.00	22.46	NA	NA
Solar PV – fixed tilt ^{8,10,11}	2020	150	2	1,698	1.05	1.00	1,783	0.00	22.46	NA	NA

¹ Represents the first year that a new unit could become operational.

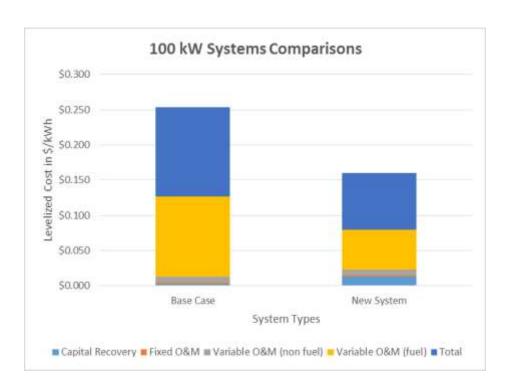
⁴ Overnight capital cost includes contingency factors and excludes regional multipliers (except as noted for wind and solar PV) and learning effects. Interest charges are also excluded. The capital costs represent current costs for plants that would come online in 2019.



² AACE International (the Association for the Advancement of Cost Engineering) has defined contingency as, "An amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs."

³ The technological optimism factor is applied to the first four units of a new, unproven design; it reflects the demonstrated tendency to underestimate actual costs for a first-of-a-kind unit.

VALUE PROPOSITION (II)



Notes

- CAPEX base ~\$400/kW and new system ~\$2000/kW
- Efficiency base ~35% and new system ~70%
- Diesel fuel, \$1.5/gallon
- Fixed O&M and variable O&M (non fuel identical)
- No cost of capital or financing assumptions made

How to win with new tech

- CAPEX will be an initial disadvantage but economies of scale can deliver improvements (need scale up partner)
- Minimize variable O&M (fuel), by enhancing efficiencies, eliminating more expensive and dirtier alternatives
- Minimize fixed O&M, reduce labor, implement digital solutions
- Minimize variable O&M (non fuel), by minimizing parts, miscellaneous materials (e.g. water), implement digital solutions
- Robust cost modeling (using aPriori, DFMA2019, PLM etc.)



CONCLUSIONS

- Global energy demand trends indicate potentially large emerging markets in Asia for systems developed under the INTEGRATE program
- Channel to market for systems in stationary power markets could be through micro-grid solution providers
- Applicability of systems proposed under the program for maritime applications requires further exploration
- Business models will impact the type of TEA that must be conducted to assess product value proposition

